THE
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Type 314 Oscillograph-record Camera Mounted on Top of a Type 279 Cathode-ray Osocillograph. The cabinet to the left of the oscillograph contains an electronic-control circuit for regulating the speed of the film.

SYNOPSIS

The article on the next page describes a new oscillograph-record camera which will considerably extend the present applications of the cathode-ray oscillograph and provide new uses for the oscillograph in those fields where it has been limited because it was primarily a visual instrument.

The following topics are discussed to assist research workers, engineers, and technicians in applying the cathode-ray oscillograph and the continuous-motion camera to their specific problems:

1. Description of the Type 314 Oscillograph-record Camera
2. Single-exposure and continuous-motion recording techniques
3. Recording films, papers, and processing techniques.
4. Cathode-ray tube screens for photography
5. Applications: (a) acoustics, (b) nuclear physics, (c) biology, (d) mechanics and hydraulics, (e) electricity, (f) radio, radar, and television.

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A New, Versatile Camera For the Cathode-Ray Oscillograph

The Du Mont Type 314 Oscillograph-record Camera*

By

H. P. Mansberg**

One of the greatest needs of those employed in scientific-research and industrial laboratories has been for a simple and efficient means for rapidly recording oscillographic patterns. Heretofore it was necessary to make sketches of oscillograms for permanent records. This method was time-consuming and subject to error; thus, the value of a versatile recording camera for producing permanent and accurate records of oscillographic patterns was early recognized.

Such traces represent either low-speed, random or recurring phenomena or high-speed transient phenomena. The oscillographic patterns of some of the non-recurring phenomena may be plotted so rapidly that visual study is impossible, even with long persistence tubes. Other patterns may be traced so slowly that the observer's memory is inadequate for maintaining continuity.

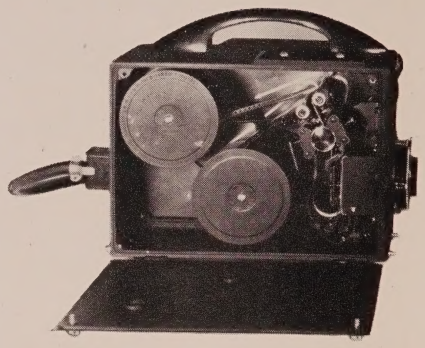

Figure 1
The Film Compartment of the Type 314 *Camera*

A camera can be used to photograph the trace of any phenomenon that can be resolved by the oscillograph sweep if the brightness of the trace is sufficient. An oscillograph-record camera specifically designed for single-exposure (still-picture) photography and some of the problems involved in oscillograph-record camera design was described in a previous issue of the "Oscillographer".*

A continuous, moving-film exposure is required for recording oscillograms of phenomena that the oscillograph sweep cannot completely display and for recording traces of changing phenomena that occur at random, or very slowly.

The Type 314 Oscillograph-record Camera, shown in the cover photograph,

* Manufactured for the Allen B. Du Mont Laboratories, Inc., by The Fairchild Camera and Instrument Corp.

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* "The Type 271-A Oscillograph-record Camera" by Carl Berkley, Oscillographer, Jan.-March, 1948, Vol. 10, No. 1.

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The purpose of this publication is to provide information on new developments and applications of the cathode-ray oscillograph and related apparatus.

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was developed by the Fairchild Camera and Instrument Co. primarily in cooperation with Allen B. Du Mont Laboratories. It is a direct result of years of experimenting with various types of cameras plus experience gained from photography of radar presentations. It incorporates a large number of practical features dictated by experience, thus making it the most versatile oscillograph-record camera available.

Description

The Type 314 Camera may be used for either still or continuous-motion photography. It is very simple to set up and operate; anyone totally unfamiliar with photographic techniques can make satisfactory recordings of high-speed transients, stationary patterns of periodically recurring phenomena, or other types of traces. The camera was designed for mounting on top of any Du Mont five-inch oscillograph so that access to all controls of the oscillograph would not be impaired. It is also possible to mount the camera on a tripod placed in front of the oscillograph. The complete Type 314 Camera consists of three basic units: the camera, a periscope and mounting-plate, and an electronic-control unit.

The Camera Unit — The lens provided as standard equipment is either an f/2.8 lens in a No. 2 Rapax shutter or an f/1.5 lens in a No. 3 Rapax shutter.

The camera employs standard perforated 35-mm film, which is driven at a uniform rate by a self-contained, magnetically shielded motor. The rate of film-movement is continuously adjustable from one inch per minute to 60 inches per second by means of a calibrated film-rate dial on the electronic-control unit shown in the cover photograph. The speed of the film can be varied by a factor of 60-to-1 by means of a simple clutch control which is located on the side of the camera; thus, it is possible to reach maximum speed of the film within a fraction of a second. Figure 1 shows the film compartment of the camera and the simple sprocket-drive mechanism. The film spools shown are 100-foot daylight-loading spools. The camera may be loaded in daylight with daylight loading film having an opaque leader and trailer. Constant speed is assured for the entire length of film by the electronic control, a slipping clutch on the take-up spool, and a mechanical filter on the motor-drive. The motor-drive and gear mechanism are located in the right side of the camera body. The camera is equipped with a manual film-transport lever so that the film may be advanced manually over lengths variable from half-frame steps to twice the height of a standard 35-mm frame (approximately 39mm). An adjustable stop, with a calibrated scale, is provided to limit the travel to the length desired.

Although the film capacity is 100 feet, provision is made for the use of 400-or 1000-foot external film magazines. With the 100-foot spools, the camera will operate for 20 seconds at maximum speed, or 20 hours at minimum speed. Using the 1000-foot magazine, the camera will operate for 3-1/3 minutes, or 8-1/3 days respectively at these extreme speeds. A footage indicator indicates the length of the exposed film.

The camera is equipped with a positive interlock so that the motor is running only while the shutter is open. For single-frame exposures, the shutter may be set for "Bulb", "Time" or any of the calibrated shutter speeds from one second to 1/400 second.

A neon timing light is mounted before the focal plane in the camera for the purpose of recording a series of dots along the edge of the film thus providing either an accurate record of film-speed, or a means of measuring time-intervals. The timing light is connected to a pair of binding posts, on the electronic-control unit, to which terminals may be applied a timing signal such as the output of a precision-frequency oscillator or an accurate intermittent pulse.

Persicope, Mounting Plate and Data Card — A specially designed mount, shown in Figure 2, locks the camera in position on top of the oscillograph; further adjustments are unnecessary. Two small spacing bars, having bayonet pins for the mount, are attached to the top of the oscillograph with four screws. An

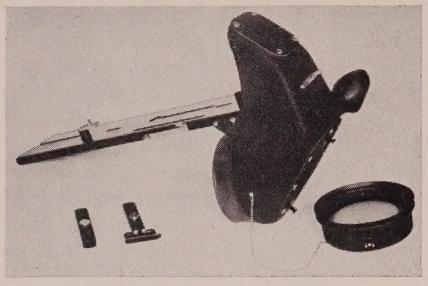


Figure 2
Mounting Plate, Spacer Mounting Bars, Periscope, and Data Card

adjustable bracket is attached to one of these spacers to provide for proper location of the mount with respect to the screen of the cathode-ray tube. Spacers also are provided to compensate for the variable distance, from the center line of the cathode-ray tube to the top of the cabinet, encountered with different models of oscillographs. Once these spacers are in place and the bracket adjusted for a particular oscillograph, they may be left permanently on the oscillograph. Each spacing bar is shock-mounted and a rubber ring-type light shield is fitted against the cathode-ray tube to minimize the effects of vibration.

Additional spacing bars may be obtained for use with other oscillographs. By releasing a snap lock, the mount and camera can be removed as a unit for rapid transfer to another oscillograph, or the camera may be removed from the mount by releasing a simple latch which, with two bayonet pins, firmly holds the camera in its correct position for photography.

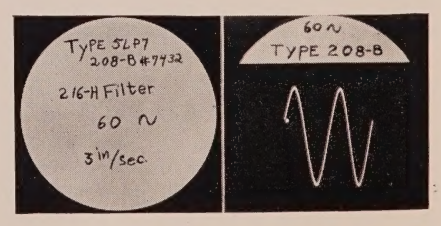
The pattern is reflected up to the lens of the camera by two mirrors in the light-tight periscope housing that is attached to the mount. The mirrors that "fold up" the light path are first-surface coated, and the amount of light lost due to the reflective coatings is negligible. This arrangement provides a'so for simultaneous viewing through a port located above the lower mirror. The rubber ring described in the foregoing is attached to the periscope; it excludes all light and insures automatic positioning for correct focus.

A shutter is provided on the viewing port to exclude all light when the port is not in use. This shutter is operated by a finger-tip control lever which is designed so that the shutter will close either automatically upon release or remain open when the lever is released.

A removable yellow filter is also provided on the viewing port to exclude blue light that would cause fogging of the film while the port is open (unless high emulsion-speed panchromatic film is used).

Data Card — The data card unit, shown in Figure 2, is provided for recording hand-written data directly on the film. This solves the important problem of identifying oscillographic records and correlating photographs with test data, thus eliminating the ever-present possibility of a mix-up of the photographic records. The data which is directly recorded on the film is as permanent as the oscillogram.

The data-card unit consists of an illuminated Lucite disk with a finely ground surface on which any data may be written with an ordinary soft-lead pencil. This disk is enclosed in a cup-shaped, sheet-metal housing that fits over the end of the periscope when the data is to be recorded; when not in use, it clips in a convenient position on the back of the periscope. To make a record of the data before or after each run, it is only necessary to slide the periscope mount out on



a *b*

Figure 3
a) A Typical Data Card Record of Handwritten Data. b) Identification of Single-frame Exposure by Means of a Data Card and Mask

its guide to a secondary position, slip the data card into place, turn on the recording lights by means of the data-card switch on the electronic unit, and trip the shutter. Figure 3a is a typical data-card record obtained by photographing hand-written data on the Lucite disk. For single-frame exposures, data may be recorded on the same frame as the oscillogram by merely using a suitable mask and making a double exposure. An example of this procedure is illustrated in Figure 3b.

Electronic-Control Unit — The electronic-control unit shown in the cover photograph contains a thyratron-rectifier circuit to control the speed of the film. A continuous speed variation of 60:1 is possible. The film speed is varied by a calibrated dial in the center of the control unit. In addition to providing a simple means for regulating the speed over a wide range, this control is designed to maintain any predetermined speed without fluctuation due to variations in load, line surges, etc.

Techniques of Recording

Single Exposures — To photograph traces of cyclical or repetitive phenomena, the shutter-speed selector on the camera lens should be set so that the shutter opens for at least the duration (preferably several times longer) of one complete cycle of the oscillograph sweep. This exposure should be long enough so that useful negative density is obtained at the points of highest writing rate.

For the photography of single transients, the shutter is usually set at "Bulb" or "Time", opened before the transient occurs, and closed after the transient has occured. For this type of photography it is best to use an oscillograph which has triggered-sweep and automatic beam-control circuits.* With such an oscillograph, the screen of the cathode-ray tube is blank before and after the transient occurs; and the trace is intensified and made visible only for the duration of the sweep. Such operation prevents fogging of the film by a luminescent spot or line before or after the transient. Table 1 contains a list of the average single-transient recording speeds possible with various Du Mont oscillographs and the Type 314 Oscillograph-record Camera.

With very long exposures on high-emulsion-speed panchromatic film, fogging of the film may occur due to the very weak glow from the heater of the cathode-ray tube. This type of fogging can easily be prevented by placing a blue filter, such as the Du Mont Type 216-H, in front of the cathode-ray tube. For more details concerning single-exposure recording, the reader is referred to the previously mentioned "Oscillographer" article.

Continuous-Motion Recording — In general, continuous-motion photography of oscillographic traces utilizes three basic techniques. The first and simplest method utilizes the motion of the film instead of the oscillograph sweep as a time base. Since the motion of the film is vertically upward in the Type 314 Camera, the variable must be plotted horizonally. Several methods may be used for obtaining horizontal deflection of the beam. It may be accomplished by supplying the signal into the X-axis amplifier, by reversing the connections to the horizontal- and vertical-deflection plates, or by rotating the cathode-ray tube clockwise through an angle of 90 degrees.

This method of recording becomes essential when the oscillographic pattern to be photographed is plotted so slowly that the observer's memory cannot provide continuity, or when the oscillograph sweep is of insufficient length to display the entire phenomenon. For example, Figure 4a shows a single-frame exposure of the starting current chaacteristics of a synchronous motor. Note that Figure 4a shows the entire transient and the tremendous variations in current, but the trace is not expanded sufficiently to study the transient in detail. The oscillograph sweep speed may be increased so that only a small expanded portion of the transient is visible as in Figure 4b. However, by making a continuous-motion recording and selecting a suitable film speed, the entire transient can be recorded upon any

* The Du Mont Types 247, 247-A, 248, 248-A, 250, 256-D, 279, and 280 have these features.

reasonable length of film, as shown in Figure 5. Note that the long time-base provided by the film enables a display of the "hunting" of the motor armature (visible as a slow modulation of the current) which cannot be seen in the single-

TABLE I

Average Single Transient Recording Speeds of Du Mont Cathode-ray Oscillographs with the Du Mont Type 314 Oscillograph-record Camera Using an f/2.8 or f/1.5 Lens

For Eastman Kodak Linagraph Pan (5244) and D-19 Developer - 9 minutes*
For Eastman, Kodak Super XX-Developed in D-19 Maximum Photographic Writing Speeds will be slightly less than the given values.

Oscillograph Type	Tube Type	Maximum Accelerating Potential volts		Maximum Photographic Writing Speed With P11 Screen			
				in/μsec		cm/μsec	
		Eb_2	Eb_3	F/2.8	F/1.5	F/2.8	F/1.5
208-B	5LP11A	1120	1400	0.08	0.32	0.2	0.8
213-A	5LP11A	1000	2000	0.314	1.25	0.8	3.2
241	5JP11A	1100	1500	0.08	0.32	0.2	0.8
247	5CP11A	1550	3000	0.8	3.2	2.0	8
247-A-263-A	5RP11A	1550	11,550	10	40	25	100
248	5JP11A	2000	4000	1.26	5	3.2	12.8
248-A-263-A	5RP11A	2000	12,000	17.3	69	44	176
250	5CP11A	1500	3000	0.8	3.2	2.0	8.0
250-H	5RP11A	1500	11,500	10	40	25	100
256-D	5CP11A	2000	4000	1.26	5	3.2	12.8
274	5BP11A	1000	1000	0.04	0.16	0.1	0.4
275-A	5CP11A	1500	3000	0.08	3.2	2	8
279	5SP11A	1700	4500	1.6	6.4	4.07	16.28
280	5RP11A	1900	11,900	15.7	63	40	160
281	5RP11A	4000	8000	14.2	57	36	144
281-263-A	5RP11A	4000	14,000	35.4	142	90	360
281-286	5RP11A	4000	29,000	70	270	76	685
288	5RP11A	1900	19,000	23.6	95	60	240

* For tank development of five-foot lengths in a tank such as the Eastman Kodak Daylight Tank. When using the Du Mont Type 2512 Film processing Unit for processing **100-foot lengths,** multiply the developing time by 2. For further instructions, see the instruction booklet included with the processing unit.

These maximum photographic writing speeds are referred to the screen of the cathode-ray tube, and are defined as the highest writing speeds of the fluorescent spot which can be photographed with the Type 314 Oscillograph-record Camera under the given conditions of accelerating potential, type of cathode-ray tube screen, film material, and processing procedure.

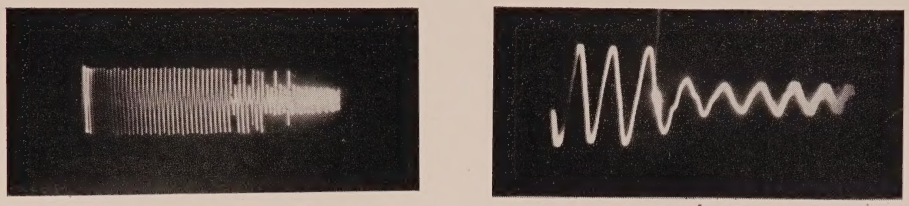
The figures are based on a minimum usable photographic density of 0.1 above film fog. These recording speeds may be obtained with an average cathode-ray tube of the type given in the table, when using fresh film stock and processed in a high emulsion-speed developer as indicated above. There are various techniques for increasing film speeds and a positive or negative deviation of 100 per cent from the figures given may be obtained depending on the brightness of the cathode-ray tube and the actual processing procedure.

Determination of Exposure for Low-speed Transients or Continuous-motion Recording—As mentioned above, the writing speeds listed would yield photographic recording densities of about 0.1 above fog. At lower writing speeds proportionately higher densities will be obtained. However, because of the film latitude and wide range of usable recording densities, over-exposure will usually not be obtained until the writing speeds are less than 1/10 that of listed values. For recording writing speeds less than 1/10 of the maximum, the effective exposure may be decreased by:

(a) stopping down the lens aperture
(b) turning down the brightness control of the oscillograph
(c) using a slower speed, fine grain film such as Eastman Kodak Panatomic X, developed in a standard developer such as D-76 (preferable method).

Repetitive Transients—Decrease the exposure proportionately to the repetition-rate increase above one time per second.

The maximum photographic writing rates specified above represent the limitations of the particular cathode-ray tube used at the operating voltages available in the oscillograph. These figures do not pertain to any frequency limitations of the oscillograph amplifiers since such specifications are included in the instruction manual for the oscillograph.



a *b*

Figure 4
a) Oscillogram Showing Single-frame Exposure of Current Starting Characteristic of a Synchronous Motor. b) Oscillogram Showing an Expanded Portion of the Transient of Figure 4a).

exposure records. This method of recording is recommended for the complete display of single non-recurrent transients. The complete display is usually difficult to show on single exposures because the first part of the trace is lost during the time required for the transient to initiate the sweep.

With this recording technique, the maximum frequency of the variable, whose oscillogram is to be recorded, is limited to approximately 10 kc by the maximum speed of the film (60 inches per second). The low film speeds available also adapt the camera to monitoring purposes. By running the camera at the lowest speed (one inch per minute) a 100-foot roll of film will run for 20 hours.

A second method of continuous recording employs the oscillograph sweep to provide a series of consecutive time bases across the width of the film as illustrated in Figure 6. The phenomenom is displayed upon these lines or time bases in the usual manner. To illustrate this technique and compare it to the first method of recording, both methods were used to record the pulses shown in Figure 7. The motion of the film functions as the time base for the upper record in Figure 7; the pulses were recorded in a vertical direction. The parallel lines below, which illustrate the second method of recording, are due to the time-base deflection with the pulses appearing in the horizontal direction. The second method utilizes more of the area of the film and provides greater spacing between the pulses. The film speed and the pulse rate were the same for both cases. For recording signals that are more complex than those shown in Figure 7, the second method should be chosen in order to utilize the available film area.

It is necessary to run the film at a speed that will provide adequate separation of the successive ocillograms corresponding to the successive sweeps. It may be observed that the time-base line appears at a slight angle to the vertical, this angle is determined by the ratio of the sweep speed, as it is optically reduced on the film, to the speed of the film. When the speed of the film and the optically reduced speed are equal, the base line records at a 45 degree angle with respect to the vertical. If the sweep speed is very much greater than the film speed, the base line becomes almost perpendicular to the motion of the film. Thus the actual velocity of the image of the spot on the film is the vector sum of the speed of the film and the writing speed of the fluorescent spot referred to the plane of the film.

The following formula may be used to

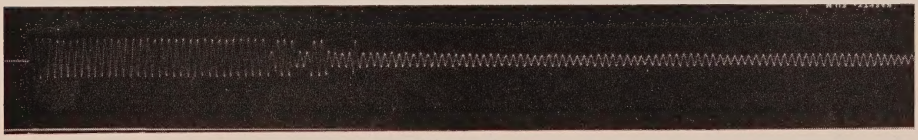


Figure 5
Oscillogram Showing a Continuous-motion Recording of the Current Starting Characteristic of a Synchronous Motor

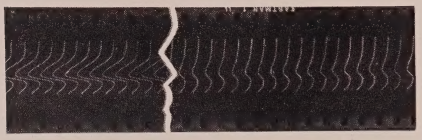


Figure 6
Oscillogram Showing the Action Potential of a Frog's Sciatic Nerve Responding to an Electrical Pulse Stimulation at a Repetition Rate of 100 Pulses Per Second—Courtesy of Dr. H. Grundfest, Columbia Medical Center, New York.

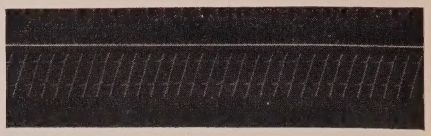


Figure 7
Oscillogram Illustrating Two Methods of Recording—The recording on the top illustrates the method utilizing the film motion as the time base, and the lower recording illustrates the use of the oscillograph sweep as a time base.

find the minimum film speed necessary to separate successive traces:

$$S = \frac{f_s h}{6}$$

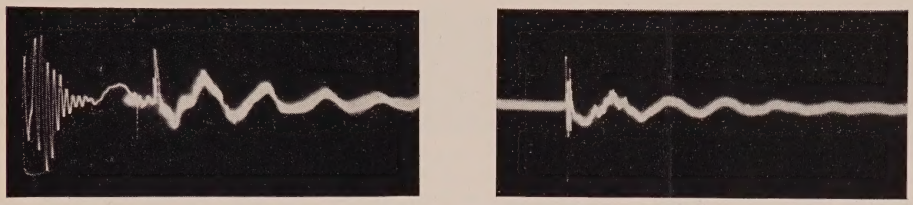
where S = the necessary film speed, in./sec
f_s = the sweep frequency, cps
h = the amplitude of the signal appearing on the cathode-ray tube screen, in.

The factor 1/6 is the optical-reduction ratio of the lens in the Type 314 Oscillograph-record Camera. If the signal being recorded has both positive and negative peaks, *h* should represent the peak-to-peak value unless the peaks of the signals for the successive sweeps "interlace". For example, to record a sine-wave trace with the peaks for one sweep interlaced with those above and below, the speed of the film could be reduced below the value obtained from the above formula. (See Figure 6). Using this second method of continuous recording, the maximum frequency of the variable whose oscillogram is to be recorded is limited only by the maximum speed of the sweep and the maximum photographic writing rate of the oscillograph.*

To record oscillograms of very rapid transients superimposed upon slowly changing signals with sufficient detail for study, it would be necessary, using the first method, to run the film at two speeds, extremely high and extremely low for the respective components. This procedure is impractical because it is virtually impossible to change the speed of the film at the right instant.

A third technique of recording includes a combination of the oscillograph sweep speed and the speed of the film to provide a complex time base. For example, in one application it was necessary to record a phenomenon which began as a rapid complex transient and concluded as a slowly changing signal. The transient initiated a single-sweep circuit in the cathode-ray oscillograph while the film was moving slowly; the direction of the sweep as referred to the film plane was the same as that of the motion of the film. Thus the speed of the resulting time base at the start was the speed of the film; and for the remainder of the record it was equal to the sum of the speed of the film and the optically-reduced sweep speed. By providing sweeps triggered by the transients and moving in a direction opposite to the direction to the motion of the film (as referred to the screen of the cathode-ray tube), it is possible to run the film at a low speed and still provide a very fast time-base. Since the motion of the film is vertically upward, the spot at the beginning of each sweep period would have to be at the top of the screen of the cathode-ray tube and the spot must be rapidly deflected downward by each transient (because of image reversal in the lens). The signal produces horizontal deflection of the spot which must remain unblanked at the end of its motion. With the use of an exponential sweep rather than a linear sweep, a dis-

* See: "A High-voltage, High-speed Oscillograph," by H. Mansberg, Oscillographer, Jan.-Feb., 1947, Vol 9, No. 1. "The Type 271-A Oscillograph-record Camera," by Carl Berkley, Oscillographer, Jan.-March, 1948, Vol. 10, No. 1.



a *b*

Figure 8
a) Shock Transient and Subsequent Oscillations of a Coiled Spring Using Combination Oscillograph Sweep and Film Motion. b) Same as Figure 8a—without using oscillograph sweep.

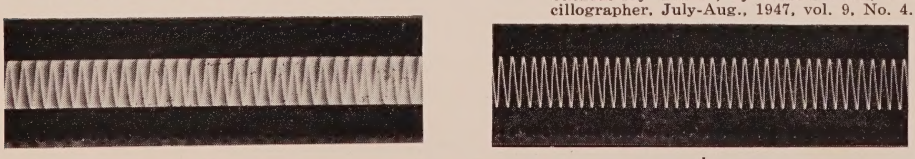
continuity in the time-base can be avoided; that is, the exponential curve of the sweep rate can be made asymptotic to the curve of the speed of the film. With this method of recording, the use of timing markers is necessary in order to achieve the proper time perspective when studying the recording. An example illustrating the usefulness of this recording method is shown in Figure 8a. This oscillogram was obtained by shocking a loaded coil spring into oscillation. The spring was loaded by suspending a Brush DP-1 displacement pickup from one end and connecting the pickup leads to the oscillograph. Note the high-frequency shock oscillations at the start of the recording and the low, natural-frequency vibrations of the spring after the shock. Note also how the great difference in writing rates causes the high frequencies to be underexposed while low frequencies are over-exposed. Figure 8b shows the recording that is obtained using the first method. Note that all detail is lost in the high-frequency oscillation while the low-frequency vibrations are displayed satisfactorily.

Fluorescent Screens for Photographic Recording — With the first method of making continuous-motion recordings of oscillographic patterns, the persistence of the phosphor of the cathode-ray tube limits the upper frequency of the waveform that can be recorded, assuming that the speed of the film is not a limiting factor. If a screen such as the medium-persistence Type P1 were used, a blurred recording (such as Figure 9a) would be obtained at relatively low speeds. For continuous-motion recording, a short-persistence phosphor such as the P11 or P5 is necessary (See Figure 9b). The maximum continuous-recording frequency which can be used for a particular phosphor is known as its "blurring limit". For the P11 phosphor, the blurring limit is appoximately 200 kc. The blurring limit of the P5 is higher, but the P11 is preferable because of its greater light output. The P2 and P7 phosphors may also be used for continuous recording if a blue filter, such as the Du Mont Type 216-H, is placed between the screen and the lens. The blue filter absorbs that part of the spectrum appearing as persistence and it transmits mainly the blue, short-persistence light.*

Types of Recording Materials and Processing

The films recommended for use with this camera are the Eastman Kodak

* See: "An All-purpose Screen For High-voltage Cathode-ray Tubes", by Rudolf Feldt, Oscillographer, July-Aug., 1947, vol. 9, No. 4.



a *b*

Figure 9
Record of an Oscillogram (60 cps) From a P1 Screen—note blurring due to persistence. b) Oscillogram (1kc) From a P11 Screen—no blurring is visible.

35-mm Types Linagraph Ortho, Linagraph Pan, Panatomic-X, and Super XX. Recording papers available in 35-mm size are Eastman Kodak Types 697, 1057, 1115 and 1127. To simplify loading and handling, the film or paper should be supplied in daylight loading spools with opaque leader and trailer. To facilitate ordering, these films or papers may be obtained by requesting Kodak Specification 39.

These films may be processed in an ordinary film developer such as Eastman D-76 when high emulsion-speed is unnecessary or when fairly fine grain is desired.

For obtaining extremely high emulsion-speeds using Linagraph Ortho and Linagraph Pan films, development should be carried out in Eastman D-19 developer. High-emulsion-speeds also may be obtained by prolonged development in D-72. See Table II for a comparison of film-emulsion and paper-emulsion speeds for oscillographic recording purposes, reltive to Panatomic X.

The Type 2512 motor-driven film-processing unit described in the section on accessories for the Type 314 Camera may be used conveniently to process 100-foot lengths of film or paper. Further discussion of film processing may be found in the previouly mentioned issue of the Oscillographer.*

Applications of the Type 314 Camera

Cathode-ray oscillographs have great application in the fields of electricity, radio, and television primarily because the phenomena to be studied exist in the electrical state. The use of transducers such as microphones, photocells, vibration pickups, particle counters, etc., have extended the application of the oscillograph to such fields as acoustics, nuclear physics,

* "The Type 271-A Oscillograph-record Camera," by Carl Berkley, Oscillographer, Jan.-March, 1948, Vol. 10, No. 1.

TABLE II

Relative Exposure Guide for Various Emulsions

Type of Film	Developer	Time—minutes[5]	Multiply Exposure by
E. K. Panatomic-X	E. K. D-76	14	1
E. K. Plus-X	E. K. D-76	16	1/3
E. K. Super XX	E. K. D-76	20	1/4
E. K. Linagraph Pan (5244)	D-19	9	1/8
E. K. Linagraph Ortho (5211)	D-19	9	1/6
Agfa Ultra Speed Pan	Agfa 47	8	1/6
Agfa Superpan Supreme	Agfa 47	7	1/4
E. K. Super XX	D-19	9	1/6
E. K. 1115 Recording Paper	D-72 1/1	1	2.2
E. K. 697 Recording Paper	D-72 1/1	1	1.5
E. K. 1127 Recording Paper	D-72 1/1	1	2
E. K. 1057 Recording Paper	D-72 1/1	1	2

1. To obtain approximate exposures for other screen types, multiply by the following factors: 3(P1), 5(P2), 2(P5), 2(P7).
2. For lower sweep speeds than those given, decrease the exposure proportionately.
3. For 100% modulated sine wave envelope.
4. For shorter sweeps, increase the exposure proportionately.
5. For tank development of five-foot lengths. When using the Type 2512 Processing unit for 100-foot lengths, multiply these developing times by 2. Further instructions are given in the instruction booklet included with the Processing unit.

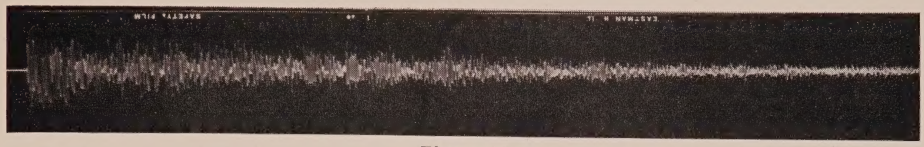


Figure 10
Oscillogram of Sound Reverberations Caused by a Sharp Sound Impulse in a Closed Room

biology, geology, mechanics, hydraulics, and geophysics. With the development of the Type 314 Oscillograph-record Camera as an oscillograph accessory, the usefulness of the oscillograph in these applications has been considerably expanded.

Acoustics — Although the oscillograph has been usd in the past to study musical and spoken sounds, the development of the Type 314 Oscillograph-record Camera provides a most convenient method for recording sound patterns for subsequent analysis.

Acoustics design engineers are continuously faced with the problem of calculating or measuring the duration and intensity of sound reflections from walls or objects in auditoriums and sound studios. Calculation of reverberation time often becomes quite complex. Usually it is necessary to measure the areas of the absorption surfaces of every unit in a room, to apply acoustical absorption coefficients to these measurements, and to include them all in a formula. Some designers use tables and nomographs to simplify these calculations.

With an oscillograph and the continuous-motion camera, a new means is available for recording and measuring reverberation time. Figure 10 is a continuous recording representing the reverberations caused by a sharp, sound impulse in a closed room. Note that this oscillogram shows the many reflections from various objects in the room and how the sound decays so gradually that a very long time base is necessary. The complete sound-decay curve is not shown here because of lack of space. This recording was made by the first method which utilizes the motion of the film as the time base. To apply this technique in acoustics design, the echoes due to a reflector may be picked up by a directional microphone, and a recording may be made showing the amplitude and location of echoes. The effect of the placement of sound damping materials can then be studied and these materials may be located in more effective positions.

Nuclear Physics — Research in nuclear physics makes use of a great many types of sensitive particle detectors, electronic counters and cathode-ray indicating equipment. The instrumentation necessary for the control of an atomic pile is exceedingly complex. Because of the danger of radiation, many types of automatic recording devices must be used. In the Bikini tests, for example, a number of recording cameras were attached to cathode-ray oscillograph indicators on ships in the danger zone.* A simple application of the Type 314 Camera is a recording of the output of a particle-counter tube. By making a continuous recording at the proper speed, it is a simple matter to count the number of particles occurring during any time interval.

The oscillogram of Figure 11 shows the output pulses of a gamma-ray counter connected to a Type 250 Cathode-ray Oscillograph. The random nature of the pulses and the bunching at various times which is often referred to as a "shower" of cosmic rays, are clearly displayed in this record. These "showers" could be further separated either by running the film at a higher rate of speed or by using the second method of recording with

* "Electronics at Bikini," by Donald G. Fink, Electronics, Nov. 1946, Vol. 19, No. 11, Pg. 84.

Figure 11
Oscillogram of the Output of a Gamma-ray Counter Tube

the oscillograph sweep as the time base.

Biology — The existence of different types of transducers for biological use has made it possible for an increasing number of medical research workers to study such physiological functions as blood-pressure variations, heart sounds, brain- and nerve-action potentials, etc. These transducers generally consist of sphygmomanometer pressure-pickup combinations, heart-sound detectors and nerve and skin electrodes, etc.

Several neurological research laboratories are at present applying the Type 314 Oscillograph-record Camera and a Type 279 Dual-beam Cathode-ray Oscillograph to the study of "nerve action potentials". Figure 6 shows a typical recording of the action potential of a frog's sciatic nerve in response to electrical stimulating pulses at a repetition rate of 100 per second. The recording was made with a Type 314 Oscillograph-record Camera and Type 247 Cathode-ray Oscillograph. The film was run at a speed of three inches per second, with each successive reaction interlaced as previously described. At the start of the stimulation a portion of the nerve was dipped into a nerve poison, and as the record continued, the reaction of the nerve to the stimuli gradually diminished.

Since the reaction was very gradual, the entire recording occupied about 100 feet of film. Only a few inches of the beginning and the end are shown in Figure 6. The trailing edge of the stimulating pulse is visible at the start of each successive sweep.

Oscillographs also are being used to study the effects of poliomyelitis and other diseases on nerve-reaction patterns. Perhaps the analysis of photographic recordings of these luminescent patterns will lead to better treatments or even cures for these afflictions. Previous neurological studies also made use of oscillographs and cameras to study the electric-pulse output of electric eels. Biological applications of the oscillograph and recording camera are by no means limited to neurological studies. The increasing use of radioactive tracer techniques will probably be enhanced by the use of recording oscillographs.

Mechanics and Hydraulics — In the fields of mechanics and hydraulics, it is often necessary to study vibrations, pressure oscillations, and dynamic unbalance. It is obvious that a suitable recording system which facilitates measurement and study of such phenomena is likely to save considerable time and expense in maintenance and design of equipment. In the case of hydraulic systems, variations in pressure may be transient and may, therefore, require a monitor type of recording system. The transducer accessories available and useful in the mechanics and hydraulics fields for use with a cathode-ray oscillograph and oscillograph-record camera are vibration pickups, inertia pickups, pressure pickups, strain gauges, etc.

At present, cathode-ray oscillographs are being used in the study of cylinder pressures of internal combustion engines. With an oscillograph record camera, it is possible to make records of cylinder pressures in automobile engines and thereby evaluate the design and operation of the engine for a given type of fuel.

Cathode-ray oscillographs and record cameras have been used with piezo-electric pick-ups to study the stresses and strains in the various parts of railroad tracks and in a lathe cutting tool while turning various types of metal stock.*

Electrical — The electrical industries are faced with an enormous number of problems to which an oscillograph and record camera combination may be applied. In the welding industry, for example, by making a continuous photographic recording of the current drawn by a seam welding machine, it is possible to evaluate the quality of the weld at various points and to check the condition of the welding electrodes.

Oscillographs are being used to adjust and analyze the performance of many types of electric motors and generators. Some of the characteristics which may be determined by the use of oscillographs are the phasing of voltages and currents in

* "Applications of Piezo-Electric Methods in Mechanical Industries," by M. Mauzin, "Mechanique," January-February, 1939.

the field and armature windings, adjustment of brushes for the least amount of sparking and radio interference, and the optimum adjustment of internal switches and contacts.

Figures 4a to 5 illustrate one type of study that may be made of the performance of synchronous motors. These oscillograms show the starting current in a synchronous motor from the instant the switch is turned on until the time the motor has reached its synchronous speed. Rapid fluctuations in motor current as the centrifugal switch throws the starter winding on and off are clearly shown. Although the single-exposure recordings show these transients very well, it was necessary to make a continuous-motion recording, as mentioned previously, to study the "hunting" characteristics of the motor as shown in Figure 5. The "hunting" of this motor was caused by starting the motor under heavy load. Timing markers on the oscillogram are unnecessary since each cycle of current represents 1/60 second. From the oscillogram it can be seen that the motor switches to the starting winding four times in a half second in order to develop sufficient torque. After the last switching occurs, the motor armature "hunts" for approximately three more seconds before stability is reached. The total elapsed time is approximately four seconds. The complete record is not shown here because of lack of space.

Figure 12 shows a recording of the starting voltage and the current drawn by a fluorescent lamp in which the lower trace represents the voltage across the fluorescent tube and the upper trace represents the total current drawn by the tube. This record was made by the first method of recording. The Type 279 Cathode-ray Oscillograph with its Type 5SP dual-gun tube provides the two channels. The two luminescent spots on the cathode-ray tube screen were positioned in a horizontal line to obtain the proper time relationship between voltage and current. When the switch is turned on, a voltage appears across the tube and a small amount of current is drawn by it. After approximately 1.4 seconds, as determined by counting the number of 60-cycle peaks, the voltage across the tube drops suddenly and the current drawn by the fixture rises to a high value. Note the six transients of voltage that correspond to light flickers in the tube as it starts and remains lighted. At the end of the recording, constant voltage and constant current, limited by the ballast and the resistance of the gas in the tube, are maintained. The slope on each voltage peak is the result of the time constant produced by gas resistance and a capacitor connected across the starter and the tube.

A recording such as this provides the fluorescent lamp manufacturer with an excellent means for evaluating the action of the gaseous starter, the tube characteristics, and for determining the optimum constants for the ballast and capacitor. Since the life of a starter and fluorescent tube depends to a great extent on the number of times that starting occurs, the study of these transients in detail is obviously desirable. This is but one example of the value of simultaneously recording dependent phenomena such as voltage-current characteristics, load-power-factor characteristics, comparison of input and output signals of amplifiers, generators, and frequency converters.

Radio, Radar, and Television — In the radio, radar, and television fields, the cathode-ray oscillograph has long been an indispensable tool. The Type 314 Oscillograph-record Camera already has shown its usefulness as an additional tool

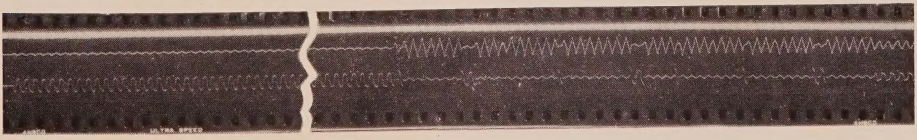


Figure 12
Oscillogram of the Starting Voltage and Current of a Fluorescent Lamp

used to further these electrical developments. By combination of the oscillograph-record camera and radar equipment, telemetering systems may be set up for recording the flights or trajectories of rocket or jet projectiles.

Oscillograph and record-camera combinations are being used for ionospheric study.* Studies of the ionosphere, wave propagation, oscillator drift, and voltage fluctuation, all require some sort of recording system. An oscillogram taken from the application of a Type 314 Camera to the study of oscillator drift is shown in Figure 13. This oscillogram was obtained by a variation of the second method of continuous-motion photography. The recurrent sweep of an oscillograph was synchronized with a standard frequency, and the output of a drifting oscillator was connected to the Z-amplifier input. The sweep then appears as a line across the film with a portion blanked out by the oscillator signal. If the frequency and phase of the oscillator are constant with respect to the standard frequency, the blanking will occur at the same point and appear as a straight blank path through the recording. In Figure 13 the oscillator frequency is seen first to drift rapidly and then become relatively stable.

Accessories for the Type 314 Oscillograph-record Camera

Type 2511 Spare Mounting Kit — It is frequently desirable to use one camera with several different oscillographs. To do this it is only necessary to have an extra set of spacing bars permanently mounted on the cabinet of each oscillograph. The camera and periscope may be removed as a unit from one oscillograph and placed on another in a few seconds. The number of additional sets of spacer bars necessary will depend on the number of oscillographs in use and the amount of recording to be done at any one time. The Type 2511 Spare Mounting Kit consists of a pair of spacing bars, a set of mounting screws, spacer washers, rubber grommets and a drilling template.

Type 2515 Magazine Adapter for 400-ft. and 1000-ft. 35-mm Film Magazines — A magazine-adapter kit for mounting standard 400-ft. or 1000-ft. film magazines on the Type 314 Camera will be available. This kit consists of a motor, a magnetic clutch with a take-up drive, mount casting and attachment bracket. The entire assembly can easily be attached without removing any part of the camera other than a metal plate, covering the film opening, which is attached with two screws. Provision is made in this adapter for automatically opening the light traps in the magazine when the film-compartment door is closed.

Du Mont Type 2512 Motor-driven Film Processing Unit—A processing unit for developing 100-foot lengths of 35-mm film is available. This equipment is automatic in operation and consists of a stainless-steel tank with light-tight cover and a motor-driven film-reel assembly.

Du Mont Type 2514 Portable Drying Rack — This dryer consists of a lightweight, collapsible reel that is quickly set up for use. It is motor-driven, and it is equipped with infra-red heat lamps to hasten drying. When not in use, it can be disassembled and stored in a compact carrying case.

* "Ionosphere Recorder," Tele-Tech, Dec. 1947, Vol. 6, No. 12, Pg. 79.

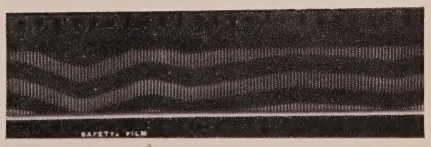


Figure 13
Oscillogram of Frequency Drift of an Oscillator

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Specifications

General—Complete instrument consists of: camera, electronic speed control, periscope cone, data card unit, and cables.

Film Capacity—Standard 100-foot roll or optional external magazines for 400-ft. or 1000-ft. rolls.

Lens and Shutter—50-mm f/2.8 Wollensak Velostigmat lens in a No. 2 Rapax shutter (f/1.5 lens optional).

Shutter speeds from one second to 1/400 second, "Time" and "Bulb" available.

Film Type—Standard 35-mm film such as Panatomic-X, Plus-X, Super XX, or the fast 35-mm recording films such as Eastman Kodak Linagraph Pan and Linagraph Ortho for photographing traces plotted at high writing speeds.

Film Speed—Continuously adjustable by electronic speed control from one inch per minute to 3600 inches per minute. Speed may be changed by a 60 to 1 ratio by means of a clutch knob.

Recording Time—For 100-foot roll: 20 seconds to 20 hours. For 1000-foot roll: 3-1/3 minutes to 8-1/3 days.

Film Drive—Electric motor drive through gear train for moving-film recording. Manual film advance for single-exposure recording.

Interlock—Interlock switch and shutter control to prevent starting of motor while making single exposures and vice-versa.

Timing—Neon lamp located in camera may be energized from an external source of any suitable frequency to provide a timing-marker track along edge af film.

Data Recording—An illuminated data card with which data may be permanently recorded on the film by using an ordinary soft-lead pencil.

Film Footage Indicator—Shows the amount of film exposed regardless of whether 100 feet or 1000 feet of film are used.

Camera Mounting—On top of oscillograph by using two simple mounting bars, mounting plate, and periscope. Tripod mounting is also possible.

Approximate Weight

Camera	15 lb.
Electronic speed control	10¼ lb.
Periscope and mount assembly	7⅜ lb.
Total	33 lbs.

Dimensions

Camera	9⅛ by 11½ by 7½ in.
Electronic control	9¼ by 10 by 5½ in.
Periscope and mount assembly	21½ by 11⅝ by 5½ in.

Power Source

Voltage	115 v
Frequency	60 cps
Power	135 w

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